GEOLOGY AND MINERAL RESOURCES OF STAFFORD COUNTY, VIRGINIA
Geologic Map Unit Descriptions
(Source: Division of Mineral Resources, 2003, Digital Representation of the 1993 Geologic Map of Virginia, – Expanded Explanation: Publication 174)

PIEDMONT

my *mylonite*. Includes protomylonite, mylonite, ultramylonite, and cataclastic rocks. Lithology highly variable, depending on the nature of the parent rock, and on intensive parameters and history of deformation. In most mapped belts of mylonite and cataclastic rock (**my**), tectonized rocks anastomose around lenses of less-deformed or undeformed rock. In the Blue Ridge, some of these lenses are large enough to show at 1:500,000 scale. In many places mylonitic and cataclastic rocks are gradational into less deformed or undeformed adjacent rocks, and location of contacts between tectonized rocks (my) and adjacent units is approximate or arbitrary. These boundaries are indicated on the map by color-color joins with superimposed shear pattern.

Most mapped belts of mylonite represent fault zones with multiple movement histories. In the Blue Ridge, Paleozoic age contractional deformation fabrics are superimposed on Late Precambrian extensional fabrics (Simpson and Kalaghan, 1989; Bailey and Simpson, 1993). Many Piedmont mylonite zones contain dextral-transpressional kinematic indicators that formed during Late Paleozoic collisional tectonics (Bobyarchick and Glover, 1979; Gates and others, 1986). Paleozoic and older faults were reactivated in many places to form extensional faults during the Mesozoic (Bobyarchick and Glover, 1979).

STRATIFIED ROCKS OF THE WESTERN PIEDMONT

OCu metasedimentary rocks, undivided (Pavlides, 1990). Gray to green phyllite, gray to white metasiltstone and fine-grained quartzite, fine-grained mica schist, green slate and phyllite, and sparse granule quartzite and graywacke; may be coeval in part with Old Mill Branch Metasiltstone Member of the Popes Head Formation (OCpo).

OCp phyllite (Pavlides, 1990). Mostly gray-to-green phyllite with lesser metasiltstone. Mylonitic rocks composed commonly of schist or phyllite with elongate granules of quartz, occur in the southern part of the outcrop belt. These are interpreted as highly tectonized parts of this formation. Alternatively, these rocks may be part of a separate terrane.

Cl Lunga Reservoir Formation (Pavlides, 1989; 1990). Metadiamictite, characterized by a nonstratified, micaceous quartzofeldspathic matrix resembling a granitoid, containing rounded to subrounded silt- to sand-sized quartz and plagioclase grains, fine-grained and porphyroblastic muscovite, green porphyroblastic biotite, garnet and magnetite. Granule-, pebble-, and cobble-sized lumps of milky quartz are ubiquitous; mica schist and gneiss clasts are common; calc-silicate clasts are rare. Pebble-, cobble-, and boulder-sized fragments of mafic and ultramafic rock are sparsely distributed in the southern part of the outcrop belt, but are locally abundant in the north. Locally along the contact with the Chopawamsic Formation, the Lunga Reservoir contains exotic fragments similar to lithologies found in the Chopawamsic. The Lunga Reservoir is intruded by Occoquan Granite.

IGNEOUS ROCKS OF THE WESTERN PIEDMONT

OCgg *Goldvein pluton* (Pavlides, 1990). Mesocratic, coarse- to medium-grained, weakly- to strongly-foliated metamonzogranite. Altered feldspars commonly impart pink and green colors to the rock. Mineralogy includes perthite and plagioclase feldspars, each locally megacrystic; granoblastic quartz, muscovite, and sparsely distributed garnet.

OCpg *plagiogranite tonalite* (Pavlides, 1990). Includes leucocratic to mesocratic plagioclase- and quartz-rich metamorphosed intrusive rocks containing little or no potassium feldspar. Plagioclase is variably altered to epidote, white mica, and chlorite. Quartz, generally blue, forms granoblastic aggregates that locally have cores of coarse-grained quartz with wavy extinction. Garnet is present locally. Hornblende, generally a minor constituent, is particularly abundant in the southwest portion of the pluton. Many of the plagiogranitic rocks have undergone cataclasis and are protomylonitic to mylonitic.

CZg *Garrisonville Mafic Complex* (Pavlides, 1990). Fine- to coarse-grained, massive to foliated amphibolite and hornblendite with lesser metapyroxenite, metawebsterite, and metanorite. Amphiboles in amphibolite are dominantly hornblende, which is poikilitic in places; actinolite and cummingtonite are present locally. Intermediate-composition plagioclase commonly shows alteration to clinozoisite or epidote. Quartz and chlorite are present in variable amounts in some amphibolites; magnetite and ilmenite are common accessory minerals. Hornblendite consists of coarse-grained hornblende in a groundmass of fine-grained hornblende, plagioclase, and quartz. At the western edge of the complex, talc-amphibole schist occurs near the contact with the country rock; metamorphic alteration is less intense in the western portion than in the east.

ROCKS OF THE CENTRAL VIRGINIA VOLCANIC-PLUTONIC BELT

PMf *Falmouth Intrusive Suite* (Pavlides, 1980). Fine grained to pegmatitic granite, quartz monzonite, granodiorite, and tonalite; consists of dikes, sills and small plutons.
Mineralogy: plagioclase + quartz + microcline + biotite + muscovite + hornblende ± garnet + epidote + apatite + titanite + opaque minerals; myrmekite common.
The unit has been dated at 300-325 Ma (U-Pb zircon and Rb-Sr whole-rock; Pavlides and others, 1982). These rocks intrude the Ta River Metamorphic Suite **(Cta)**, Falls Run Granite Gneiss **(Sf)**, Holly Corners Gneiss **(CZh)**, Quantico Formation **(Oq)** and porphyroblastic garnet-biotite gneiss (**Ym**; Po River Metamorphic Suite of Pavlides, 1980).

Sf *Falls Run Granite Gneiss* (Pavlides, 1980). Pink to white, coarse-grained, strongly-foliated hornblende-biotite granite to monzonite gneiss.
Mineralogy: microcline + plagioclase + quartz + biotite + muscovite ± hornblende; apatite, epidote, titanite, and magnetite-ilmenite are accessories; myrmekite is common.
The Falls Run has been dated at 410 Ma (U-Pb zircon and Rb-Sr whole-rock; Pavlides and others, 1982); the gneiss intrudes Ta River Metamorphic Suite **(Cta)** and the Holly Corners Gneiss **(CZh)**.

Quantico Formation (Oq, Oqq; Pavlides, 1980)
Oq *slate and porphyroblastic schist.* Gray to black, graphitic, pyritic phyllite and slate (northern Piedmont); metamorphic grade increases to the southwest to produce porphyroblastic staurolite-,

kyanite-, and garnet-biotite-muscovite schists. Locally the unit contains felsic metatuff, metagraywacke, and micaceous quartzite interbeds; thickness has been estimated at as much as 3000 feet (Pavlides, 1980).
Mineralogy: quartz + muscovite + biotite ± garnet ± staurolite ± kyanite + opaque minerals; chlorite is a common secondary mineral.
Geophysical signature: strike-elongated positive linear magnetic and radiometric anomalies.
The unit was originally named Quantico Slate by Darton (1894), and modified to Quantico Formation by Pavlides(1980). An Ordovician age for the Quantico is indicated by fossils collected by Watson and Powell (1911) and more recently by Pavlides and others (1980). The Quantico unconformably overlies older units in the northeastern Piedmont, and is correlated with the Arvonia Formation to the southwest.

Oqq *micaceous quartzite.* Light-gray, fine- to medium-grained quartzite and quartzose muscovite schist.

OCtj *trondhjemite* (Pavlides, 1990). Light-gray, leucocratic, fine-grained, allotriomorphic-granular; composed of intergrown albite and quartz exhibiting granophyric texture. Blue-green amphibole and garnet are present locally.

Ccv *Chopawamsic Formation, undivided*, (Pavlides, 1981). Includes laterally discontinuous lenses and tongues of metamorphosed felsic, intermediate, and mafic volcanic flows and volcanoclastic rocks, with interlayered quartzite, quartzose greywacke, schist, and phyllite. Volcanic flows are locally highly vesicular; fragmental breccia and tuff are common. Felsic flows are typically light-gray aphanitic rocks with phenocrysts of quartz and feldspar; intermediate flows are dark-green amphibole-bearing rocks with fine-grained quartz-feldspar matrix; greenstone metabasalts contain blue green amphibole, chlorite, albitic plagioclase, and quartz.
Geophysical signature: linear strike-elongate pattern of elevated magnetic anomalies.
The Chopawamsic is correlated with the James Run Formation in Maryland; the James Run has been dated at 570 to 530 Ma (U-Pb zircon; Tilton and others 1970). The Chopawamsic is unconformably overlain by the Late Ordovician Arvonia and Quantico Formations. Pavlides (1981 and subsequent works) has made the interpretation on the basis of geologic and geochemical data that the Chopawamsic and related plutons represent an ancient island-arc sequence.

Cta *Ta River Metamorphic Suite, (undivided)*. Layered sequence consists dominantly of greenish-gray to black, medium- to coarse-grained, poorly to well-lineated, massive to well-layered amphibolite and amphibole-bearing gneiss and schist; includes interlayered ferruginous quartzite, and minor biotite gneiss, felsic volcanic rocks, gabbro and granite. Amphibolitic rocks commonly contain quartz-epidote lenses and veins. Proportion of biotite gneiss and schist increases from northeast to southwest along strike, as does grade of regional metamorphism.
Mineralogy: (hornblende, tremolite-actinolite, and cummingtonite) + quartz + calcic oligoclase ± epidote ± biotite ± garnet.
Geophysical signature: linear positive and negative magnetic and radiometric anomalies.
Pavlides (1981) correlated the Ta River with the Chopawamsic and James Run Formations, and considered the Ta to be a more oceanward facies of a Chopawamsic island arc sequence, on the

basis of geologic and geochemical factors. The Quantico Formation generally overlies the boundary between the Chopawamsic and the Ta, obscuring the contact relationships.

Cg *amphibole metagabbro*. Dark-greenish-gray, coarse-grained, massive, hornblende metagabbro.
Mineralogy: plagioclase + hornblende + biotite + clinopyroxene + quartz; relict olivine and myrmekitic intergrowths of quartz in other minerals are characteristic.
Geophysical signature: small circular areas marked by positive magnetic anomalies.
Metagabbro intrudes Ta River Metamorphic Suite.

CZh *Holly Corner Gneiss* (Pavlides, 1980; 1990). Dark- gray to black, fine- to medium-grained, strongly-foliated hornblende-biotite-rich gneiss.
Mineralogy: hornblende + plagioclase + biotite + quartz + titanite; accessory minerals include zircon, epidote, microcline, chlorite; trace amounts of apatite, calcite, muscovite, and opaque minerals are present. Myrmekitic intergrowths are common.

dgn *quartz diorite gneiss*. White to gray, fine- to medium grained, massive to layered quartz diorite gneiss, contains minor biotite and epidote; lenses of gray to black, medium-grained, layered hornblende-plagioclase gneiss and quartz-epidote clinopyroxene-hornblende-plagioclase gneiss occur locally (Tobisch, 1972).

ROCKS OF THE EASTERN PIEDMONT

Ymd *porphyroblastic garnet-biotite gneiss.* Heterogeneous layered sequence is dominantly garnetiferous biotite gneiss and porphyroblastic gneiss, migmatitic in part, with subordinate interlayered amphibolite and amphibole gneiss (**Ya**), pelitic-composition gneiss, calcsilicate gneiss, biotite-hornblende-quartz-plagioclase gneiss, and garnetiferous leucogneiss. These lithologies contain amphibolite-facies metamorphic mineral assemblages consistent with rock chemistry. Farrar (1984) reports relict granulite-facies assemblages in some rocks.
This unit underlies a wide area that surrounds the State Farm antiform (Poland, 1976; Reilly, 1980; Farrar, 1984) and two subsidiary antiforms to the northeast; the unit includes the Maidens gneiss and portions of the Sabot amphibolite of Poland (1976), the eastern gneiss complex and Boscobel granodiorite gneiss of Bobyarchick (1976), and the Po River Metamorphic Suite of Pavlides (1980). Poland(1976) and Reilly(1980) proposed that the Maidens gneiss and Sabot amphibolite were a Late Precambrian- to Early Paleozoic-age volcanic-sedimentary cover sequence unconformably overlying the State Farm gneiss. Farrar (1984) interpreted relict granulite-facies mineral assemblages to have equilibrated during Grenville-age regional metamorphism; this contributed to his conclusion that the Sabot and Maidens, in addition to the State Farm, are Grenville or pre-Grenville in age. Porphyroblastic garnet-biotite gneiss (**Ymd**) is intruded by rocks of the Carboniferous-age Falmouth Intrusive Suite (Pavlides, 1980).

COASTAL PLAIN

al *alluvium (Holocene).* Fine to coarse gravelly sand and sandy gravel, silt, and clay, light- to medium-gray and yellowish-gray. Deposited mainly in channel, point-bar, and flood plain environments; includes sandy deposits of narrow estuarine beaches, and mud, muddy sand, and

peat in swamps and in fresh- and brackish-water marshes bordering tidewater rivers. Grades into colluvium along steeper valley walls at margins of unit. Mostly Holocene but, locally, includes low-lying Pleistocene (?) terrace deposits. As much as 80 feet thick along major streams.
sp swamp deposits (Holocene). Reddish-brown fibrous peat, brown to black sapric peat, and peaty mud and sand. Constitutes fill of extensive, shallow, poorly drained Dismal Swamp basin southwest of Portsmouth. Radiocarbon ages from lower part of peaty fill indicate sediment accumulation began about 12,000 yrs B.P. (Otte and Smith, 1985). Thickness generally less than 10 feet.

Qt *Tabb Formation, undifferentiated* (upper Pleistocene, Johnson, 1976). Sand, silt, and peat of coast-parallel plains seaward of the Suffolk and Harpersville scarps, includes coeval terrace deposits along major river valleys west to Fall Line. Subdivided into three members (Johnson, 1976).

Qsh *Shirley Formation* (middle Pleistocene, Johnson and Berquist, 1989). Light- to dark-gray, bluish-gray and brown sand, gravel, silt, clay, and peat. Constitutes surficial deposits of riverine terraces and relict bay mouth barriers and bay flood plains (altitude 35-45 feet) inset below depositional surfaces of the Chuckatuck Formation (Johnson and Peebles, 1984). Upper part of unit is truncated on the east by the Suffolk and Harpersville scarps; locally, lower part occurs east and west of scarps. Fluvial-estuarine facies comprises (1) a lower pebble to boulder sand overlain by (2) fine to coarse sand interbedded with peat and clayey silt rich in organic material, including in-situ tree stumps and leaves and seeds of cypress, oak, and hickory, which grades upward to (3) medium- to thick-bedded, clayey and sandy silt and silty clay. Marginal-matrix facies in lower James River and lowermost Rappahannock River areas is silty, fine-grained sand and sandy silt containing Crassostrea virginica, Mulinia, Noetia, Mercenaria, and other mollusks. Astrangia from lower Rappahannock River area has yielded a uranium-series age of 184,000 ± 20,000 yrs B.P. (Mixon and others, 1982). Thickness is 0 to 80 feet.

Qcc *Charles City Formation* (lower Pleistocene (?), Johnson and Berquist, 1989). Light- to medium-gray and light-to dark-yellowish and reddish-brown sand, silt, and clay composing surficial deposits of riverine terraces and coast-parallel plains at altitudes of 70 to 80 feet. Unit is adjacent to, and inset below, the Windsor Formation and older deposits. Bay or shallow-shelf facies of the Charles City (Johnson and Peebles, 1984), present beneath flat to gently seaward-sloping plain in Suffolk area, includes a thin, basal, gravelly sand grading upward into fine- to medium-grained sand and an uppermost clayey and sandy silt; lower and middle parts of unit contain clay-lined, sand-filled burrows. Fluvial-estuarine facies in terrace remnants along major rivers consists of cross-bedded gravelly sand and clayey silt. Thickness is 0 to 55 feet, or more.

QTw *Windsor Formation* (lower Pleistocene or upper Pliocene, Coch, 1968). Gray and yellowish- to reddish-brown sand, gravel, silt, and clay. Constitutes surficial deposits of extensive plain (altitude 85-95 feet.) seaward of Surry scarp and of coeval, fluvial-estuarine terraces west of scarp. Fining-upward sequence beneath plain consists of a basal pebbly sand grading upward into cross-bedded, quartzose sand and massive, clayey silt and silty clay; lower and upper parts of sequence were deposited, respectively, in shallow-marine or open-bay and restricted-bay or lagoonal environments. In terraces west of Surry scarp, fluvial-estuarine deposits comprise muddy, coarse, trough cross-bedded sand and gravel grading upward to sandy silt and clay. Thickness is 0 to 40 feet.

Tb1 / Tb2 *Bacons Castle Formation* (upper Pliocene, Coch, 1965).Gray, yellowish-orange, and reddish-brown sand, gravel, silt, and clay; constitutes surficial deposits of high plain extending from Richmond, eastward to the Surry scarp. Unit is subdivided into two members: **Tb1**, massive to thick-bedded pebble and cobble gravel grading upward into cross-bedded, pebbly sand and sandy and clayey silt, and **Tb2**, predominantly thin-bedded and laminated clayey silt and silty fine-grained sand. Tb2 is characterized by flaser, wavy, and lenticular bedding and rare to common clay-lined burrows including Ophiomorpha nodosa. Thickness is 0 to 70 feet.

Tc *Chesapeake Group* (upper Pliocene to lower Miocene, Darton, 1891). Fine-to coarse-grained, quartzose sand, silt, and clay; variably shelly and diatomaceous, deposited mainly in shallow, inner- and middle-shelf waters. Ages of units based on studies of foraminiferal, nannofossil, diatom, and molluscan assemblages in Virginia and adjacent states (Andrews, 1988; Gibson, 1983; Gibson and others, 1980; Poag, 1989; Ward and Blackwelder, 1980; Ward and Krafft, 1984). Includes the following formations, from youngest to oldest:

Chowan River Formation (upper Pliocene, Blackwelder, 1981). Gray to dusky blue-green sand, fine- to medium-grained, clayey and silty, commonly very shelly; grades laterally into laminated, silty clay and upward into cross-bedded, biofragmental sand, clayey silt, and silty clay. Discontinuous pebbly to bouldery sand at very irregular base of unit. Mollusks include Glycymeris hummi, Noetia carolinensis, and Carolinapecten eboreus bertiensis. Thickness is 0 to 50 feet. Recognized only in southeasternmost Virginia and North Carolina.

Yorktown Formation (lower upper Pliocene to lower Pliocene, Clark and Miller, 1906). Bluish-gray and brownish-yellow sand, fine- to coarse-grained, in part glauconitic and phosphatic, commonly very shelly, interbedded with sandy and silty blue-gray clay. In lower York and James River basins, unit includes cross-bedded shell hash. Mollusks include Glycymeris subovata, Chesapecten jeffersonius, Chesapecten madisonius, Mercenaria tridacnoides, Panopea reflexa. Coarse-grained sand and gravel facies of the Yorktown in up dip areas is mapped separately as unit psg. Thickness is 0 to 150 feet.

Eastover Formation (upper Miocene, Ward and Black-welder, 1980). Dark-gray to bluish-gray, muddy sand, very fine to fine, micaceous, interbedded with sandy silt and clay. Lower part of unit is dominantly medium- to very-thin-bedded and laminated silt and clay interbedded with very-fine sand, lenticular and wavy bedding common; upper part is mainly very-fine- to fine-grained sand containing abundant clay laminae. Typical mollusks include Chesapecten middlesexensis, Marvacrassatella surryensis, Glossus fraterna. Thickness is 0 to 270 feet.

St. Marys Formation (upper and middle Miocene, Shattuck, 1902). Bluish- to pinkish-gray, muddy, very-fine sand and sandy clay-silt, locally abundantly shelly. Chesapecten santamaria, Buccinofusus parilis, and Ecphora gardnerae are characteristic mollusks. Occurs northeast of Mattaponi River. Thickness is 0 to 40 feet.
Choptank Formation (middle Miocene, Shattuck, 1902). Olive-gray sand, fine to very-fine, clayey and silty, shelly, and diatomaceous clay-silt; commonly forms fining-upward sequences. Mollusks include Chesapecten nefrens, Mercenaria cuneata, Ecphora meganae. Thickness is 0 to 50 feet.

Calvert Formation (middle and lower Miocene, Shattuck, 1902). Commonly consists of 2 to 7 fining-upward sequences. Each sequence includes a light- to dark-olive-gray basal sand, very fine to fine, clayey and silty, very sparsely to abundantly shelly; grades upward to sandy, diatomaceous clay-silt and diatomite. Typical mollusks include Chesapecten coccymelus, Crassatella melinus, Ecphora tricostata. Thickness is 0 to 600 feet.

psg *Pliocene sand and gravel*. Interbedded yellowish-orange to reddish-brown gravelly sand, sandy gravel, and fine to coarse sand, poorly to well-sorted, cross-bedded in part, includes lesser amounts of clay and silt in thin to medium beds. Commonly caps drainage divides (altitude 250-170 feet) in western part of Coastal Plain. Lower part of unit, showing flaser and lenticular bedding and containing rare to abundant Ophiomorpha nodosa, represents deposition in marginal-marine environments and is, in part, a near shore equivalent of the more down dip, marine facies of the Yorktown Formation. In the northern part of the Coastal Plain, the more poorly sorted and less cleanly washed upper part of unit, which lacks fossils, comprises fluvial-deltaic sediments that prograded eastward across the shelf during a regressive phase of the Yorktown. To the south, the upper part of unit is massively bedded clayey sand in places containing heavy mineral concentrations that average 8 percent or more; the sands are near shore, beach and dune origin; interstitial clay was derived, in part, from in-situ weathering of feldspar sand. Thickness is 0 to 50 feet.

msg *Miocene sand and gravel.* Fine- to coarse-grained sand, sandy gravel, silt, and clay, gray to light-yellowish-gray, commonly oxidized to yellowish-orange and yellowish-brown; pebbles and cobbles are deeply etched. Commonly caps interfluves at northwestern edge of Coastal Plain and constitutes thin Coastal Plain outliers in easternmost Piedmont where deposits directly overlie weathered crystalline rocks. In part, may represent a fluvial to marginal-marine facies of the Choptank Formation. Thickness is 0 to 30 feet.

Tl *Lower Tertiary deposits* (Oligocene, Eocene, and Paleocene). Mostly fine- to coarse-grained glauconitic quartz sand and clay-silt, shelly in part; includes lesser amounts of sandy limestone and limey sand. In outcrop, unit comprises the Pamunkey Group (Brightseat, Aquia, Marlboro, Nanjemoy, and Piney Point Formations) and the Old Church Formation. In subsurface, unit includes Eocene and Oligocene strata not included in the Pamunkey and Old Church. Ages of formational units based on foraminiferal, nannofossil, dinocyst, pollen, and molluscan studies (Frederiksen, 1979; Gibson and others, 1980; Gibson and Bybell, 1984; Edwards, 1984, 1989; Edwards and others, 1984; Poag, 1989; Ward, 1985; Ward and Krafft, 1984). Stratigraphic sections vary widely, comprising one or more of the following formations:

Old Church Formation (Ward, 1985) and unnamed glauconitic sands (upper Oligocene). In inner and middle Coastal Plain, unit is 0 to 5 feet of olive-gray, fine- to coarse-grained, shelly, very sparsely glauconitic quartz sand of the Old Church Formation; typical fossils include Anomia ruffini, Lucina sp., and Mercenaria capax. In subsurface of outer Coastal Plain, unit includes about 45 feet of dark-olive-gray to greenish-black glauconite sand with lesser amounts of quartz; sand has olive-brown clay-silt matrix.

Lower Oligocene beds. Olive-gray to grayish-olive sand, very-fine-grained, clayey and silty, micaceous, glauconitic; coarsens upward to a very-fine- to fine-grained sand. Unit is 0 to 50 feet

thick; identified only in subsurface of Eastern Shore area (Exmore, core hole, R. B. Mixon and D. S. Powars, personal communication).

Chickahominy Formation (upper Eocene, Cushman and Cederstrom, 1945). Predominantly olive-gray clayey silt and silty clay, very compact, glauconitic, micaceous, contains abundant finely crystalline iron sulfide. Coarsens downward to a very-fine- to fine-grained sand, pebbles at base. Rare fragmental shell, microfossils very abundant. Thickness is 0 to 100 feet; present in subsurface of southeastern Virginia.

Piney Point Formation (middle Eocene, Otton, 1955). Olive-gray and grayish-olive-green, glauconitic quartz sand, medium-to coarse-grained, poorly sorted, contains scattered quartz pebbles, interbedded with carbonate-cemented sand and moldic limestone. Unit is characterized by large, calcitic shells of the oyster Cubitostrea sellaeformis, a middle Eocene marker. Aragonitic mollusks are generally leached, leaving only molds and casts. Thickness is 0 to 60 feet.

Nanjemoy Formation (lower Eocene, Clark and Martin, 1901). Dark-olive-gray, greenish-gray, and olive-black glauconitic quartz sand, fine- to coarse-grained, very clayey and silty, intensely burrowed, sparsely to abundantly shelly, interbedded with sandy clay-silt. Sand in upper part of unit is less clayey, very micaceous, and contains scattered quartz pebbles. Typical mollusks include Venericardia potapacoensis, Venericardia ascia, and Macrocallista subimpressa. Unit is 0 to 140 feet thick.

Marlboro Clay (lower Eocene (?) and upper Paleocene, Clark and Martin, 1901). Light-gray, pinkish-gray, and reddish-brown kaolinitic clay, massively bedded to laminated, interbedded with lesser amounts of laminated and ripple cross-laminated silt and very-fine-grained sand. Contains rare molds of small mollusks and arenaceous foraminifera. Thickness is 0 to 30 feet.

Aquia Formation (upper Paleocene, Clark and Martin, 1901). Light- to dark-olive gray, glauconitic quartz sand, fine- to coarse-grained, clayey and silty, thick- to massively bedded, sparsely to abundantly shelly. Lower part of unit is more poorly sorted and more calcareous than upper part and contains a few thin to medium beds of olive-gray, white, and pale greenish-yellow limestone. Upper part of unit is moderately well sorted and characterized by thin beds of the large, high-spired gastropod Turritella mortoni. Other common mollusks include Cucullaea gigantea, Ostrea sinuosa, and Crassatellites alaeformis. Thickness is 0 to 130 feet.

Brightseat Formation (lower Paleocene, Bennett and Collins, 1952). Olive-gray to olive-black, micaceous quartz sand, fine- to very fine-grained, clayey and silty, variably glauconitic. Thickness is 0 to 20 feet.

Kp *Potomac Formation* (Lower and Upper(?) Cretaceous, McGee, 1886). Light-gray to pinkish- and greenish-gray quartzo-feldspathic sand, fine- to coarse-grained, pebbly, poorly sorted, commonly thick-bedded and trough cross-bedded. Sand is interbedded with gray to green, massive to thick-bedded sandy clay and silt, commonly mottled red or reddish-brown. Includes lesser amounts of clay-clast conglomerate and thin-bedded to laminated, carbonaceous clay and silt. In the inner Coastal Plain, unit was deposited mainly in fluvial-deltaic environments, intertongues eastward with thin glauconitic sands of shallow-shelf origin. Spore and pollen

assemblages and leaf impressions of ferns and cycads indicate an Early Cretaceous age (Doyle and Robbins, 1977). In some down dip areas, uppermost part of unit may be of earliest Late Cretaceous age. Thickness ranges from a featheredge at western limit of outcrop to more than 3500 feet in subsurface of outermost Coastal Plain.